

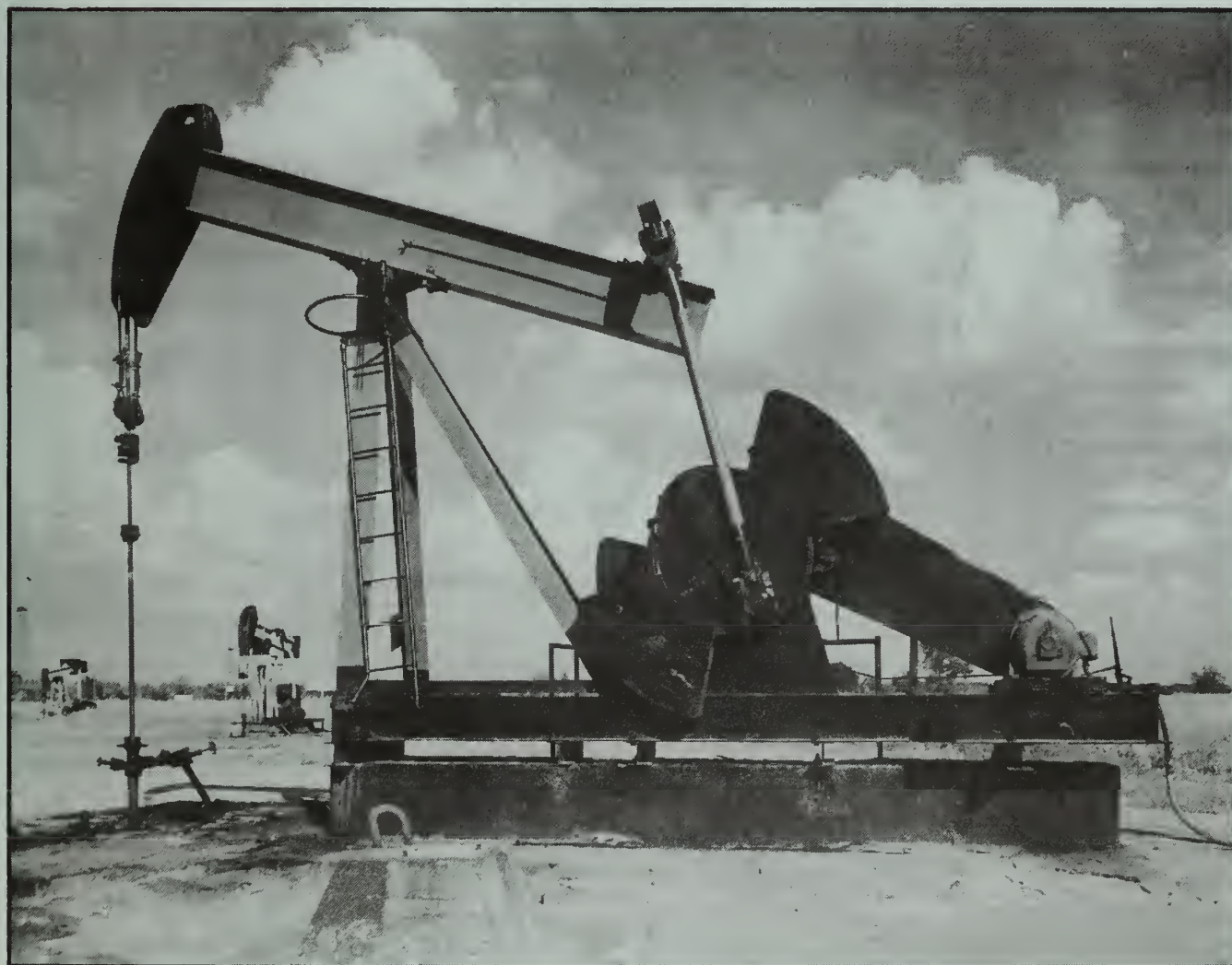
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Geol Survey

Oil:1980

an analysis of the current situation
from an international, national and Illinois perspective

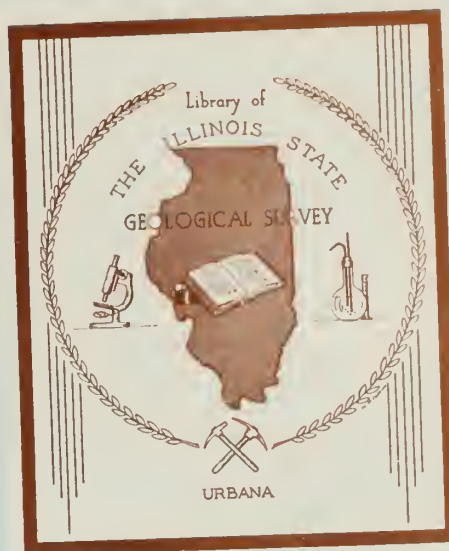
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Illinois Institute of Natural Resources
STATE GEOLOGICAL SURVEY DIVISION
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ABSTRACT

The world's recoverable oil reserves have not increased since the 1973 oil embargo and the dramatic price increases that followed, and oil reserves in the United States have actually declined. Yet world oil production has increased over the last three decades. The United States, Western Europe, and Japan depend heavily on oil imports from the Organization of Petroleum Exporting Countries (OPEC)*. While significant new oil discoveries in Europe have enabled some European nations to decrease their dependence on OPEC, the United States has become increasingly dependent on OPEC since 1973.

It is estimated that oil supplied about 45 percent (133 quadrillion** Btu) of the 295 quads of energy consumed in the world in 1978. Total energy consumption in the United States in 1978 was about 79 quads or about 27 percent of the world total.

About 50 percent of the oil consumed in the United States is used for motor fuels and about 17 percent for electricity generation. Private cars alone account for about 33 percent of the total oil consumption.

Prices for domestically produced oil have not reflected the high production costs resulting from low oil well productivity in the United States in comparison with Middle Eastern oil fields. However, the oil price decontrol that began in June 1979 is expected to increase domestic oil prices (which now range between \$6.00 and \$15.00 per barrel) to international levels by December 1981. OPEC pricing policies, the declining exchange value of the dollar in relation to other currencies, and domestic inflation in the United States appear to be mutually related.

Less than 0.5 percent of the nation's oil reserves are in Illinois, and no more than 1 percent of the national oil production comes from this state. However, Illinois consumes 4 percent of the total oil consumed in the United States; the consumption rate of private cars in Illinois is higher than the national average. Virtually all Illinois oil production qualified for price decontrol in June 1979 because of the low average productivity (about 3 barrels per well per day). Prospects of higher oil prices have stimulated drilling activity in Illinois as in the United States as a whole over the last 3 years. More increases are expected as oil prices are entirely decontrolled by December 1981.

World oil resources are probably large enough to allow for an orderly transition to new forms of energy over the next 50 to 70 years; however, the price of oil will be substantially higher.

**OPEC, founded in 1960 on the initiative of Venezuela, currently includes the following countries. Abu Dhabi/United Arab Emirates, Iran, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, Algeria, Nigeria, Indonesia, Gabon, Ecuador, and Venezuela. With the exception of Gabon, Ecuador, and Venezuela, the OPEC countries are predominately Islamic by religion.*

***1 quadrillion Btu = 10^{15} Btu = 1 quad*

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OIL RESERVES AND PRODUCTION

The world's proven oil reserves increased from about 76 billion barrels in 1950 to about 712 billion barrels in 1975, but declined to approximately 642 billion barrels in 1979 (fig. 1). The ratio of the reserves to yearly production increased from 20:1 in 1950 to about 40:1 in 1958, then declined to about 29:1 in 1968. The present ratio of reserves to production is about 30:1. Since 1972 there have been only insignificant changes in world oil reserves. Obviously, the drastic increases in crude oil prices since 1973 have not resulted in significant new discoveries of oil throughout the world.

Oil reserves in the United States increased from about 25 billion barrels in 1950 to about 32 billion barrels in 1960 and remained nearly constant during the 1960-1970 period (fig. 2). The Prudhoe Bay oil discoveries of 1968 added 9.6 billion barrels to these reserves in 1971, but by 1979 reserves had declined to about 28 billion barrels. The ratio of United States reserves to production typically varied between about 11:1 and 12.5:1 between 1950 and 1978. However, the ratio declined considerably in the latter

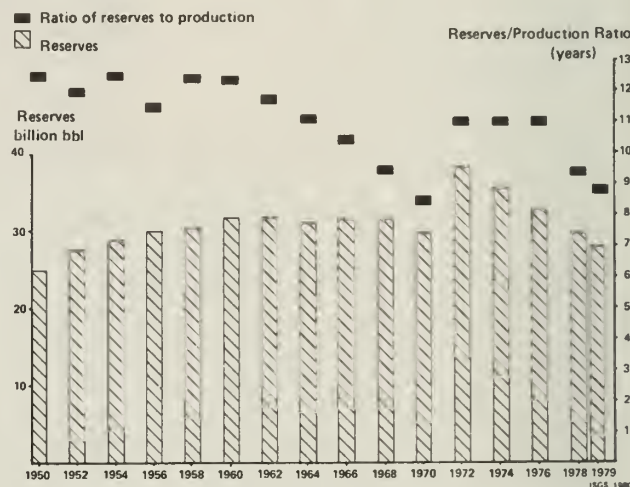


Figure 2. United States oil reserves and reserves-to-production ratio. Source of data: API.

half of the 1960s (reaching 8.4:1 in 1970), rose to about 11:1 in 1972, and remained constant through 1976. Between 1977 and 1978 reserves were considerably depleted, and the ratio of reserves to production had dropped to 9.3:1 in 1978. In 1950 oil reserves in the United States accounted for 32 percent of world oil reserves; the United States share has dropped steadily over the last three decades, reaching 4.3 percent in 1979.

World oil production (about 3.8 billion barrels in 1950) doubled in a decade, increasing at a rate of 7.2 percent per year between 1951 and 1960. Between 1961 and 1970 world oil production increased at an annual rate of about 8.1 percent, reaching 16.72 billion barrels in 1970; however, since 1971 the rate of increase in the world's oil production has sharply declined, averaging about 3.7 percent per year between 1971 and 1979. In 1979 world oil production was estimated to be about 23.1 billion barrels.

In 1950 United States oil production (about 2 billion barrels) accounted for more than 61 percent of the world oil production. Over the next two decades United States production rose continuously, reaching 3.5 billion barrels in 1970; however, in 1970 this production accounted for only about 21 percent of world oil production. In 1978 the

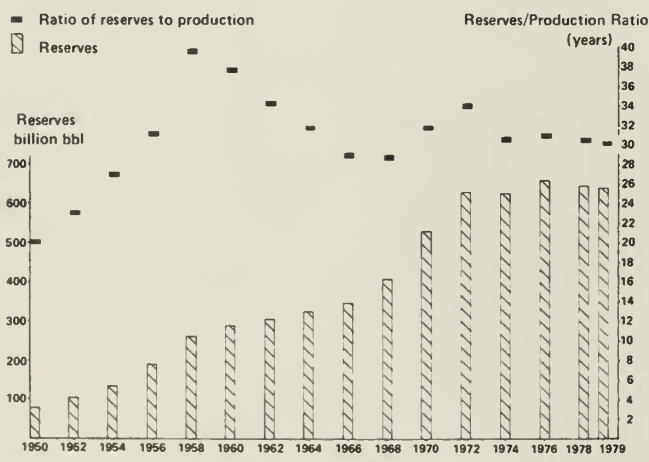


Figure 1. World oil reserves and estimates of future resources. Source of data: American Petroleum Institute (API).

an analysis of the current situation from an international, national and Illinois perspective

United States produced about 3.2 billion barrels of oil, about 14 percent of the world's total. Preliminary estimates for 1979 suggest that oil production in the United States has slightly declined from the previous year.

The world has become increasingly dependent upon the Organization of Petroleum Exporting Countries (OPEC) during the last 20 years. Approximately 70 percent of the world oil reserves are in OPEC countries (this percentage has not changed significantly in the last 20 years). OPEC's share of world oil production has increased from 40 percent in 1960 to 50 percent in 1979. Although the Middle East's share of world oil reserves has declined since 1954, about 56 percent of world reserves and about 80 percent of OPEC reserves are located there (fig. 3). Middle Eastern countries account for about 50 percent of OPEC production.

WORLD OIL CONSUMPTION BY AREAS

It is estimated that oil supplied about 45 percent (133 quadrillion Btu) of the 295 quads of energy consumed in the world in 1978. Total energy consumption in the United States in 1978 was about 79 quads or about 27 percent of the world total (fig. 4). Oil accounted for about 49 percent of the total energy consumed in the United States. In other words, the United States consumes about 29 percent of the world's oil and produces only about 14 percent of the world's oil. As the world's largest oil importer, the United States in 1978 imported about 3 billion barrels.

Other major oil-consuming areas of the world are Western Europe, the East European Communist Bloc, and Japan. In 1978 these regions consumed about 23 percent, 19 percent, and 8.5 percent, respectively, of the world production. Western European countries as a group imported more oil than did the United States. In 1978, Western Europe imported 4.3 billion barrels of oil, 85 percent of its total oil consumption. In the same year Japan imported about 1.8 billion barrels of oil, virtually all the oil it consumed.

HIGHLIGHTS

World oil production has increased continuously over the last three decades; however, the *rate of increase* in the world oil production has declined since 1971.

There has been no increase in the world's recoverable oil reserves since the 1973 oil embargo and the dramatic price increases that followed. Oil reserves in the United States have actually declined.

OPEC countries produce about 50 percent of the world's oil and have about 70 percent of the world's oil reserves. Significant new oil discoveries in Europe have enabled some European nations to decrease their dependence on OPEC oil.

The United States has become increasingly dependent on OPEC since 1973; in 1978 about 80 percent of her crude oil imports came from OPEC. The United States is currently consuming about 29 percent of the world's oil, while producing only about 14 percent.

Nearly 50 percent of the oil consumed in the United States is used for motor fuels (33 percent for private cars alone); about 17 percent is used to generate electricity.

In 1950, 32 percent of the world's oil reserves were in the United States; in 1979, only 4.3 percent. In spite of increased oil drilling in the United States (from 27,500 holes in 1973 to 48,500 in 1978), reserves continue to decline.

An average Middle Eastern oil well produces nearly 280 times more oil daily than an average oil well in the United States.

Traditionally, prices for domestic oil have not reflected the high production costs resulting from low oil well productivity in the United States (in comparison with Middle Eastern well productivity). But the oil price decontrol that began in June 1979 is expected to increase domestic oil prices to international levels by December 1981.

Illinois produces less than 1 percent of the nation's oil and has less than .5 percent of the nation's oil reserves, yet consumes 4 percent of the total oil consumed in the nation. Virtually all Illinois oil production qualified for price decontrol in June 1979 because of the low average productivity (about 3 barrels per well per day).

Domestic inflation in the United States and the declining exchange value of the dollar in relation to other currencies appear to be mutually related to the world oil price increases, since the dollar serves as the basis in all oil transactions.

Prospects of higher oil prices have stimulated drilling activity in Illinois (as in the United States as a whole) over the last 3 years. More increases are expected as oil prices are entirely decontrolled by September 1981.

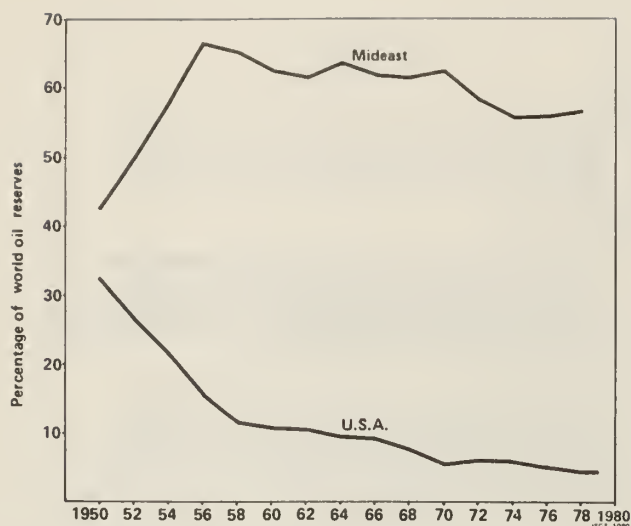


Figure 3. Middle East and United States oil reserves as percentages of world total. Source of data: API.

OIL CONSUMPTION IN THE UNITED STATES

United States oil consumption has risen from about 14.5 million barrels per day in 1970 to about 18.8 million barrels per day in 1978. Oil imports have increased even faster, from about 25 percent (3.5 million barrels per day) of total consumption in 1970 to about 48 percent (8.2 million barrels per day) in 1978 (fig. 6).

The percentage of petroleum consumed for transportation in the United States has not changed appreciably since 1948. For example, in 1948 transportation accounted for about 52 percent; in 1978 transportation's share was about 53 percent. In contrast, the percentage of petroleum products (excluding gas) used for electricity generation has tripled over this period, rising from about 3.5 to about 10.5 percent, and the percentages for residential, industrial and commercial uses have declined (fig. 6).

About 70 percent of the petroleum used in transportation is consumed by passenger cars (fig. 7) and most of the rest by trucks; less than 1 percent is used for public transportation. Most electricity in the United States is generated by burning coal (fig. 8). However, it is interesting to note the rise in oil use for electricity generation after 1965 and its continuation even after the oil crisis of 1973/74. In 1977 about 17 percent of the total electricity in the United States was generated by burning oil, in comparison with about 6 percent in 1965. The increased use of oil for generating electricity can be partly attributed to the declining use of high sulfur coal prompted by the 1970 Clean Air Act and in part to the reduced use of natural gas for this purpose.

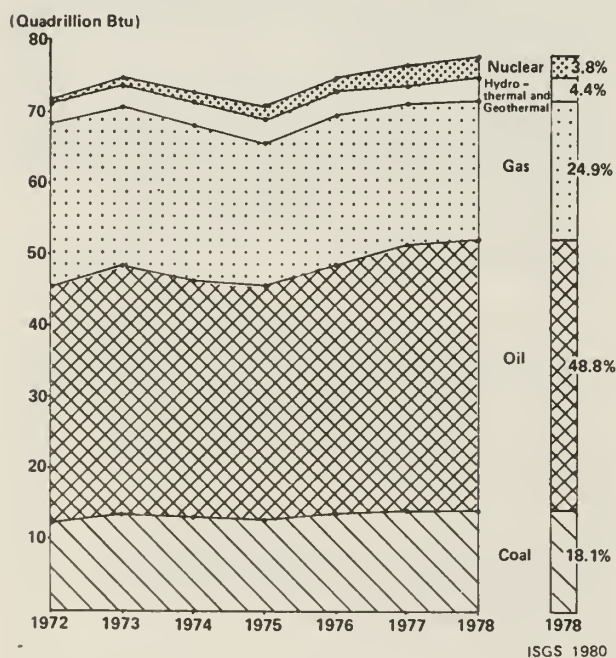


Figure 4. United States energy consumption by primary energy type. Source of data: U.S. Department of Energy (DOE): Annual Report to Congress, 1978.

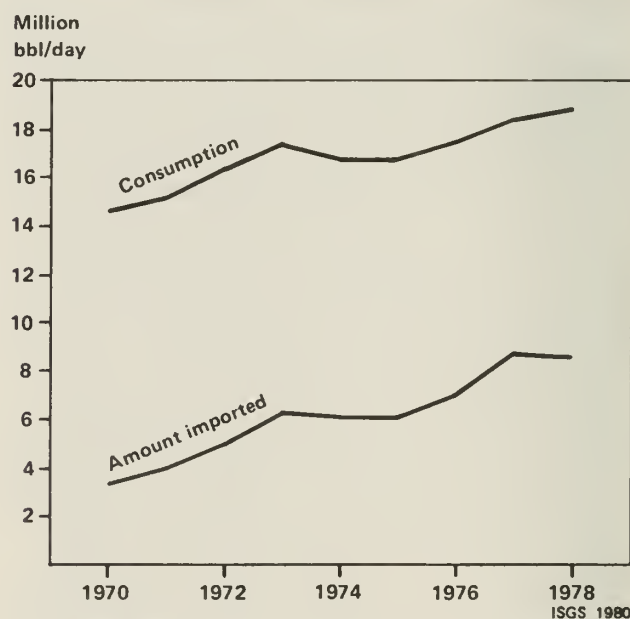


Figure 5. United States domestic consumption (of refined petroleum products) and percentage of consumption imported. Source of data: API.

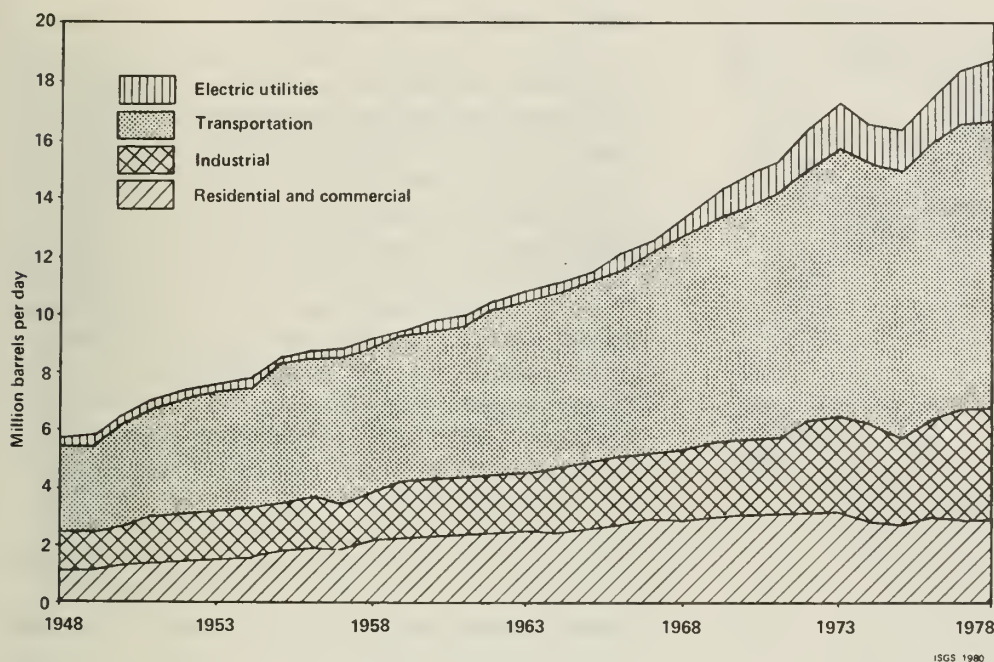


Figure 6. United States consumption of refined petroleum products by end-use sector. Source of data: DOE.

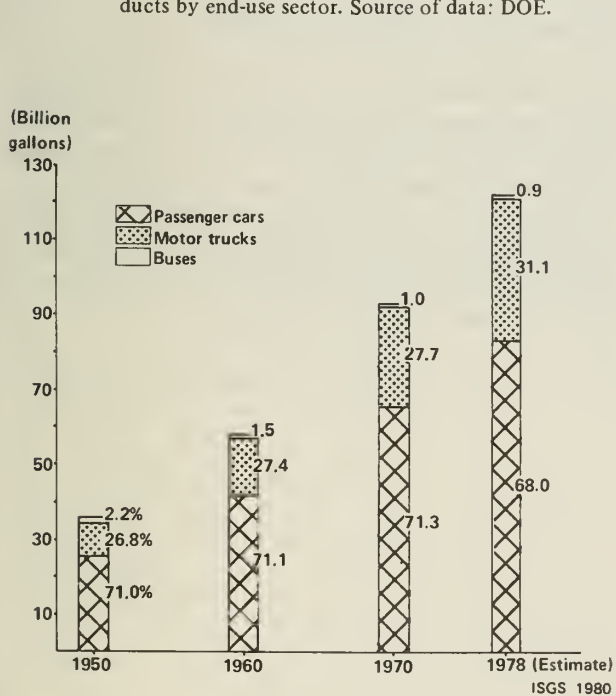


Figure 7. Consumption of motor fuels in the United States. Source of data: API.

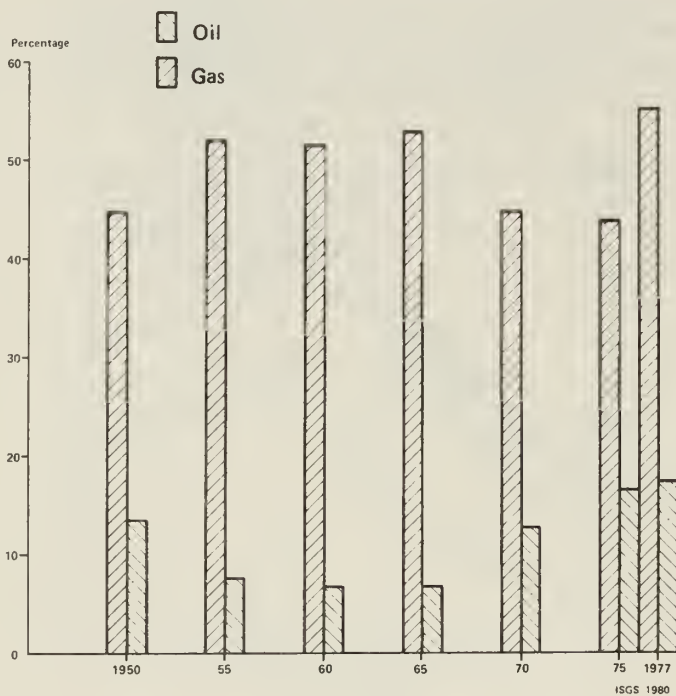


Figure 8. Electricity generation in the United States: Percentage of coal and oil used (on basis of heat input). Source of data: API.

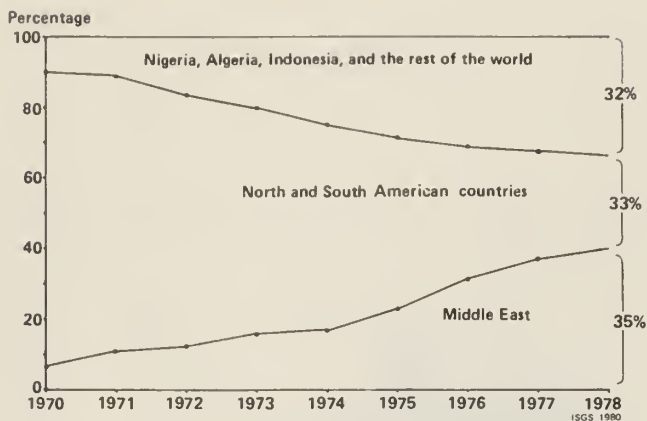


Figure 9. United States petroleum imports by source (1978 figures estimated). Source of data: DOE.

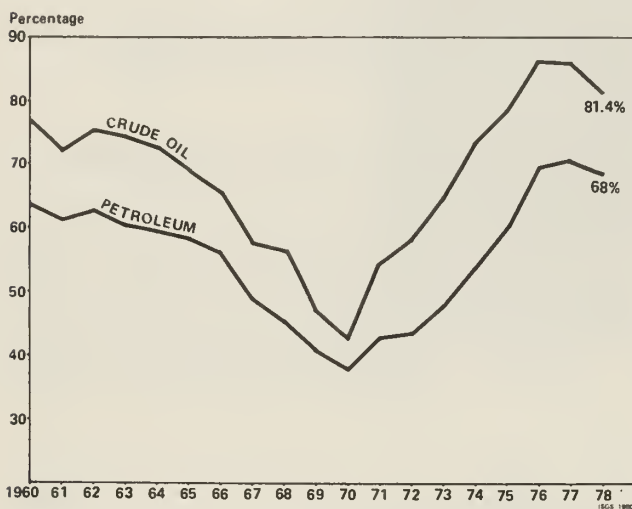


Figure 10. United States petroleum and crude oil imports from OPEC. Source of data: API.

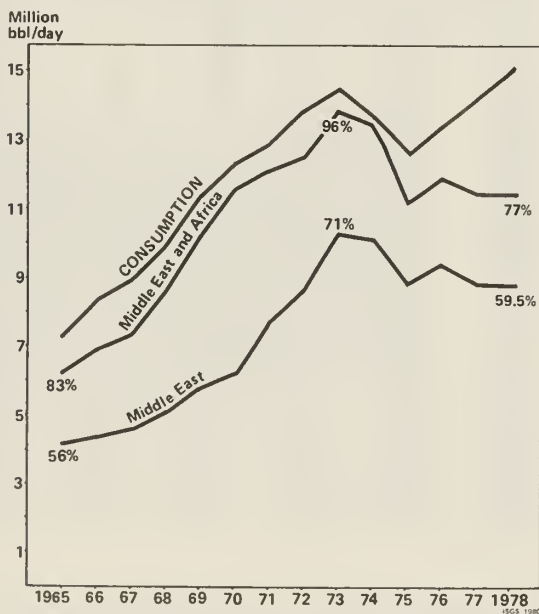


Figure 11. European consumption of Middle Eastern and African oil. Source of data: API.

UNITED STATES OIL IMPORTS

In 1970 nearly 84 percent of the petroleum imported by the United States came from countries in the western hemisphere (fig. 9). By 1978 only 33 percent was coming from the western hemisphere, while the Middle East was supplying about 35 percent. The remaining 32 percent was delivered mainly by Nigeria, Algeria, and Indonesia.

Between 1960 and 1970 United States dependence on OPEC for crude oil and petroleum products declined from about 77 and 64 percent, respectively, to about 42 and 38 percent, mainly because of increased imports from Canada and the Dutch West Indies. However, these two countries reduced their exports to the United States in the 1970s, and rising demand for oil in the United States after 1970 led to increased imports from OPEC (fig. 10) despite oil price increases. In 1978 about 81 percent of the crude oil and 68 percent of the petroleum products imported by the United States came from OPEC; because of this heavy dependence, price increases or supply disruptions from any OPEC nation affect the United States severely.

CONTRASTS IN IMPORT PATTERNS

Other leading industrial nations of the western world also depend heavily on oil imports. West European countries import about 85 percent of the oil they consume each year, and Japan is almost entirely dependent on imported oil.

Since 1973, however, the European nations and Japan have been able to reduce their dependence on the Middle Eastern and African oil, primarily because of significant new oil discoveries in the North Sea area.

The Middle east and Africa supplied about 96 percent of the oil consumed by Europe in 1973 (fig. 11), but in 1978, as oil production from the North Sea increased, this share had declined to about 77 percent (with the Middle East providing about 60 percent). Since European oil consumption has continued to rise for three successive years (1976 to 1978), it is obvious that increased European oil production, notably from the offshore fields of the United Kingdom and Norway, has contributed to growing European independence from Middle East oil.

The Japanese have traditionally imported most of their oil from the Middle East; however, in 1968 they began to import more from other areas, particularly Indonesia (fig. 12), reducing their dependence on Middle East oil to about 74 percent in 1978.

WORLD OIL ECONOMICS

The production of oil is a highly capital-intensive process involving expensive equipment for drilling and production. Most equipment used in the Middle East and other oil-producing countries is manufactured in the industrialized nations of the world. Thus, under comparable geographic surroundings, there should not be very great differences in the specific drilling costs (per foot drilled) in various parts of the world. However, as conditions onshore and offshore differ greatly, as do conditions in extreme climates such as the north slope of Alaska, drilling costs do vary widely. Average 1977 drilling costs in the United States ran about \$50 per foot, with the average depth of hole 4,853 feet (fig. 13). The cost of drilling and equipping well increases rapidly below a depth of 5,000 feet. Approxi-

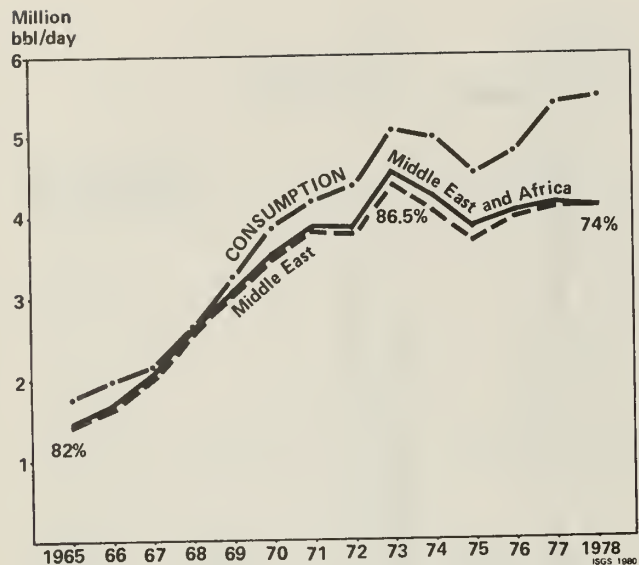


Figure 12. Japanese consumption of Middle Eastern and African oil. Source of data: API.

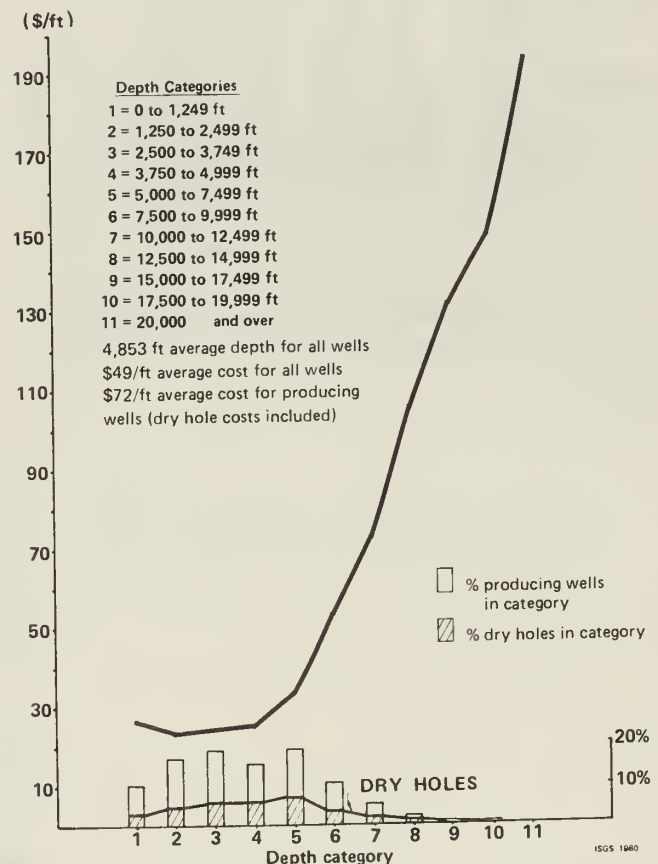


Figure 13. United states drilling and equipping costs. Source of data: Matheny, *Oil and Gas Journal*.

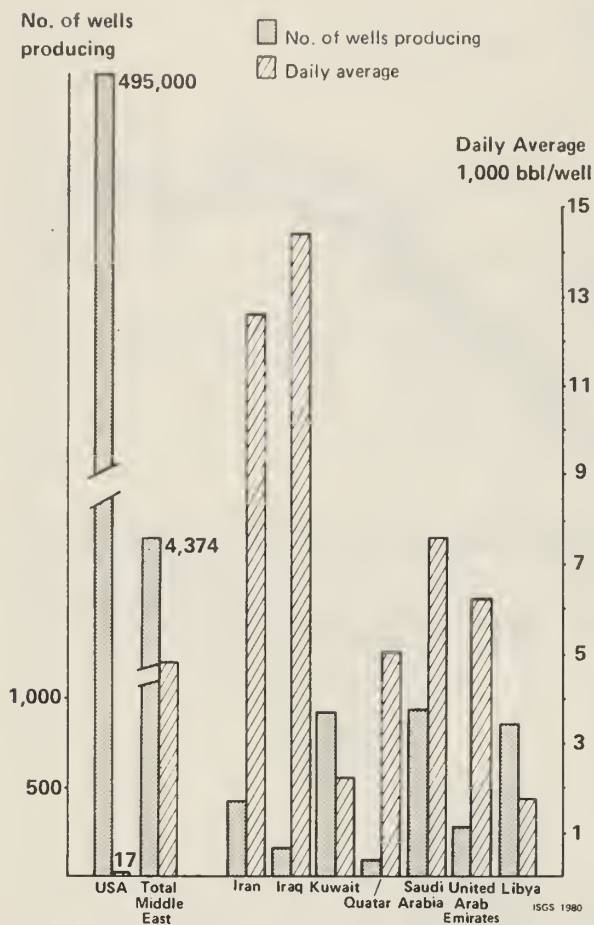


Figure 14. Oil well productivity in the United States and Middle East (1975 data). Source of data: Exxon.

mately a third of all the holes drilled in 1977 in the United States produced no oil, thereby causing a significant rise in the cost per productive well. Costs have been escalating at an average annual rate of about 15 percent since 1973.

United States oil fields are low in productivity in comparison with those of the Middle East (fig. 14). In 1975 an average oil well in the United States produced about 17 barrels of oil daily, whereas an average well in the Middle East produced about 4,800 barrels daily. The most productive oil wells of the world, located in Iraq and Iran, produced daily averages of about 14,500 barrels and 12,700 barrels per well in 1975. Thus, in 1975 fewer than 5,000 Middle East oil wells produced more than twice as much oil as did nearly 500,000 United States oil wells. However, United States oil prices have traditionally not reflected the great cost differences resulting from low well productivity in the United States (fig. 15). The controlled well-head oil price in the United States between 1960 and 1973 was about \$1.00 per barrel higher than the sale price of the Middle East oil. Considering transportation costs, for foreign oil the delivered prices of domestic and imported oils did not differ significantly until 1973.

The oil embargo related to the Arab-Israeli conflict of 1973 triggered a temporary supply shortage along with skyrocketing price increases; however, the controlled prices of domestic oil did not rise as much as those of imported oil. In 1974, imported oil was priced at about \$12 per barrel and domestic oil was about \$6.50 per barrel. Both domestic and imported oil prices have been rising since 1974. From 1974 to December 1979 prices for

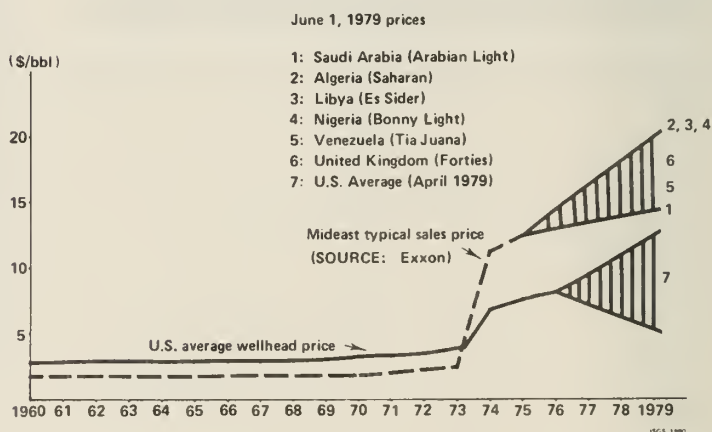


Figure 15. Average prices (range of averages since 1975) for United States and Middle East oils. Source of data: Exxon.

foreign oil have risen to \$24-\$30 per barrel. Domestic oil is presently undergoing a step-by-step price decontrol, to be completed by September 1981. Some categories of oil wells in the United States, such as the so-called stripper wells (producing less than 10 barrels per day), have already been exempted from price controls in order to stimulate oil production from older and less productive wells. It is estimated that stripper wells accounted for about 15 percent of the total United States oil production in 1979. Prices for decontrolled oil in the United States increased to about \$35.00 per barrel at the end of 1979. Domestic oil prices still under government control (about 85 percent of total production) range from about \$6.00 to \$15.00 per barrel, and are expected to catch up with imported oil by the end of 1981. As a result, the average price of all oil consumed in the United States will probably double by December 1981.

Although the formation of OPEC, the oil embargo associated with the Arab-Israeli conflicts, and the Iranian Revolution have undoubtedly contributed to the surge in oil prices, they have not been responsible for all the price increases. In the three decades since 1949, international oil prices have risen from around \$2.00 to about \$30.00 per barrel (an average annual price rise of 9.4 percent). A major portion of these price rises can be attributed to the general worldwide rate of inflation and the declining value of the dollar. The oil producers actually were receiving diminishing returns for their oil (in terms of buying power) from 1948 until 1973, because during this time, prices in current United States dollars remained unchanged. Inflation aver-

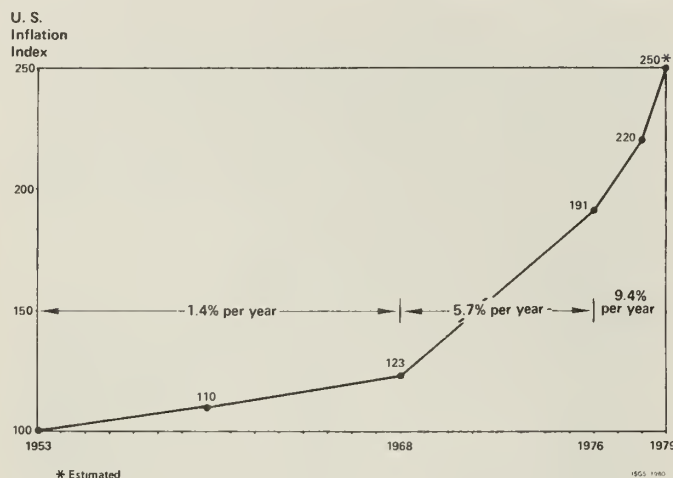


Figure 16. United States inflation index, 1953-1979. Source of data: *World Oil*.

aged 1.4 percent per year in the United States from 1953 to 1968; 5.7 percent per year from 1968 to 1976; and 9.4 percent per year during the 1976 to 1979 period (fig. 16).

Oil price increases have had less impact in Japan and Western Europe because the United States dollar, used for all oil sale transactions, has depreciated relative to other important currencies of the western world. The exchange rate for the German Deutsche Mark (DM) (nearly 4 DM to 1 United States dollar in 1969) declined to about 1.8 DM to 1 dollar by July 1979 (fig. 17). In other words, Germany

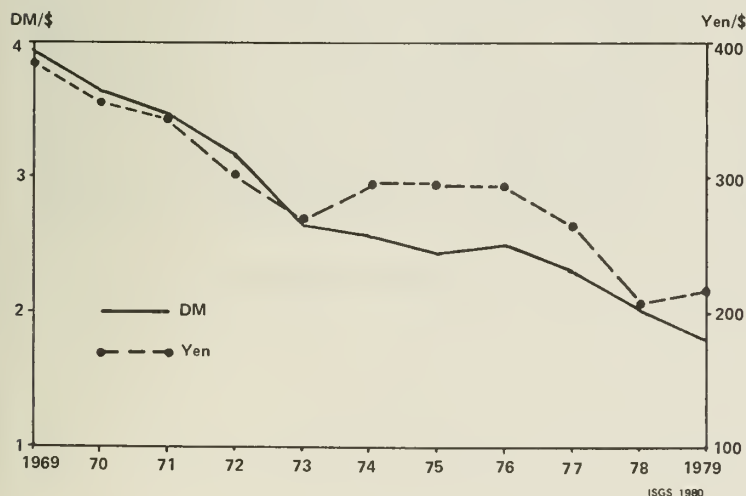


Figure 17.

Exchange rates for German Mark and Japanese yen in United States dollars. Source of data: Deutschen Bundesbank, 1979.

paid about 12 DM (3 United States dollars) for 1 barrel of oil in 1969 and about 32 DM (18 United States dollars) per barrel in July 1979. From 1969 to July 1979, therefore, oil prices in United States dollars increased 500 percent; but in Germany, the rise was only about 170 percent. An almost identical development occurred in Japan: in terms of yen, the United States dollar in July 1979 was worth only about one-half its 1969 average value.

However, world oil prices increased by about 65 percent between June 1979 and January 1980, reaching \$30 to \$35 per barrel (depending upon the source and quality of oil). As there has been no significant change in the exchange value of the dollar relative to other currencies in the latter half of 1979, consumers in Japan and Europe have been affected to the same extent as consumers in the United States.

FUTURE PROSPECTS

It is clear that the world will have to seek alternative sources of oil and other energy in the future. Although there is limited availability of the conventional types of oil which can be recovered economically through primary recovery methods, it appears certain that higher oil prices would make it economically feasible to drill deeper, drill in more remote areas, and use more expensive, enhanced recovery methods to increase the amount recoverable. While only about 30 percent of the original oil in place can be recovered through primary methods, additional in-place oil can be recovered by applying secondary recovery methods. From one-third to two-thirds of in-place oil can be recovered, depending upon the methods of recovery, the physical characteristics of the oil-bearing formation, and the oil itself. Any improvement in this rate of recovery would, of course, add to available oil reserves. Caution is warranted, however, about overly high expectations for the discovery of new oil fields. Experience of the last 6 years has shown that despite the sharp price increases, world oil

reserves have not increased appreciably (fig. 1) and United States reserves have actually declined at the fastest rate since 1950 (fig. 2). Based on actual reserves, past rates of new reserves discovery, and yearly production, in the United States during the past 20 years, recoverable United States total oil reserves may be limited to about 170 billion barrels (Hubbart, 1979).

Oil drilling in the United States increased from about 27,500 holes in 1973 to 48,500 in 1978 (fig. 18); however, the decline in reserves shows that the increased drilling has not resulted in sufficient oil to compensate for the yearly depletion of reserves through production.

According to P.W.J. Wood (1979), world oil resources are large enough to allow an orderly transition to other forms of energy over the next 50 to 70 years; however, the geographic location of the yet undiscovered oil deposits and the types of oil found there will make them more difficult and more expensive to recover. On a short term basis, the reserves development is subject to technical, economical, and political forces.

Preliminary estimates by the *Oil and Gas Journal* (December 31, 1979) put the 1979 world oil production at

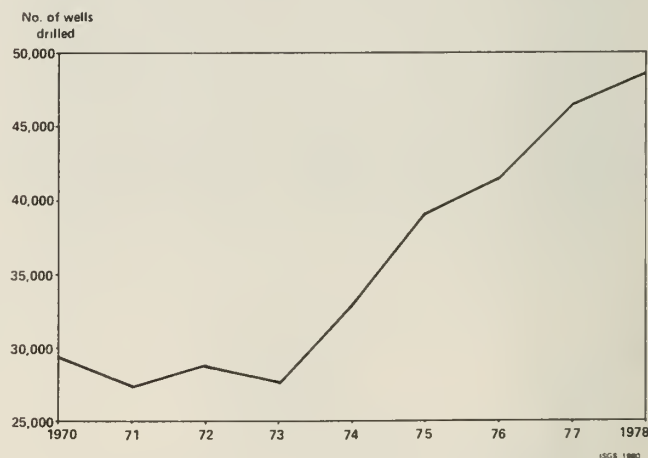


Figure 18. United States oil drilling activities. Source of data: API.

an average 62.6 million barrels per day, as compared with 60.3 million barrels per day in 1978. In spite of the Iranian oil cutback, the Middle East produced about the same amount of oil in 1979 as in 1978.

Although higher oil prices are partly responsible for the increased world oil production, the overwhelming dependence of most oil producing countries on oil exports as a means of earning foreign currency has played a very significant role in keeping supplies adequate. The Middle Eastern and African countries have been exporting between 85 and 100 percent of their oil production since 1961 and some of them may not be able to cut back production significantly without harming their economies. A greater balance between world oil demand and supply would help bring about a greater stability in the price of oil, but to achieve a balanced demand and supply, at least two strategies would have to be carried out simultaneously. One strategy is to reduce the use of oil and oil products through various options such as conservation, increased efficiency of use, higher prices and substitution of oil through other fuels on a world-wide basis; another strategy is to increase the domestic and world oil supply from conventional and unconventional sources.

THE ILLINOIS OIL SITUATION

Illinois oil reserves (less than 0.5 percent of total United States reserves) declined from 175 million barrels in 1972 to about 138 million barrels in 1979. Illinois oil production reached its highest level in 1940 with 148 million barrels, but has since declined considerably, to an estimated 21 million barrels in 1979. The ratio of oil reserves to production in Illinois was about 6.6:1 in 1979.

Since 1965, oil has accounted for about 35 percent of the total energy consumption in Illinois, according to the Institute of Natural Resources and the Department of Business and Economic Development (1979). In 1977 about 4.2 quads of energy were consumed in Illinois.

About 250 million barrels of oil were consumed in Illinois in 1977 and only about 25 million barrels of this total were produced within the state; in other words, Illinois annually consumes about 10 times as much oil as it produces. In 1977 the following percentages of energy used by each sector of Illinois' economy came from oil:

	Percentage of total Illinois energy consumption	Percentage accounted for by oil products
Transportation	23	22.50
Electric utilities	25	2.00
Industrial	19	3.00
Residential	18	3.25
Commercial	13	5.10
Agriculture	2	2.00
	100	37.85

These figures indicate that almost all the energy used in transportation and agriculture came from oil or oil products, and that nearly 40 percent of the commercial energy use was based on oil. The Illinois consumption pattern differs from that of the United States as a whole in the following ways:

About 90 percent of the oil consumed in Illinois is imported from other states and foreign countries, while only about 48 percent of the total oil consumed in the United States is imported.

About 42 percent of the oil consumed in Illinois is burned by private cars, in comparison with a 36 percent national average.

Prior to 1970, only about 2 percent of the electricity generated in Illinois was oil based; about 3 percent came from nuclear reactors. In 1977 about 8 percent of the total energy used by the electric utilities in Illinois to produce electricity came from oil and 29 percent was nuclear

(fig. 19). Consumption of natural gas for electricity generation declined, both in absolute and relative terms, from about 16.5 percent in 1970 to about 1.5 percent of the total in 1977.

The wellhead prices of oil produced in Illinois have been higher than the United States averages. In 1976, the average barrel of crude oil produced in Illinois was priced about \$10.20 as compared with a United States average of about \$8.15 per barrel. The 1978 Illinois price for crude oil averaged \$13.70 per barrel, while the United States average was \$10.00 per barrel. From June 1979 onward oil price decontrol would qualify most Illinois oil wells to charge open market prices because of their low production per well. The daily per well oil production in Illinois has declined from about 7.1 barrels in 1947 to about 6.7 barrels in 1957, 5.7 barrels in 1967 and about 3.0 barrels in 1977. Thus, average wellhead value of Illinois oil in 1979 is estimated to have reached \$20 per barrel.

Oil is produced in about 40 of the 101 counties in Illinois, according to data reported in *Petroleum Industry in Illinois (1978)*. About 75 percent of oil production comes from the following 10 southeastern counties: Clay, Crawford, Fayette, Jefferson, Lawrence, Marion, Richland, Wabash, Wayne and White. About 40 percent of the oil produced in Illinois is recovered by primary methods and about 60 percent by secondary methods. Waterflooding is the most widely applied secondary method, accounting for about 59 percent of total oil production in Illinois. Pressure maintenance projects report about 1 percent of

total Illinois production. The number of drilling rigs operating in Illinois declined from 30 in 1967 to 6 in 1973; the number of holes drilled decreased from 1,331 in 1967 to 611 in 1973. Since the oil crisis of 1973 drilling activity has increased appreciably. (In 1978 about 28 drilling rigs were operating, completing 1,142 drill holes.) However, additional oil discoveries have generally been inadequate to increase the oil reserves of the state.

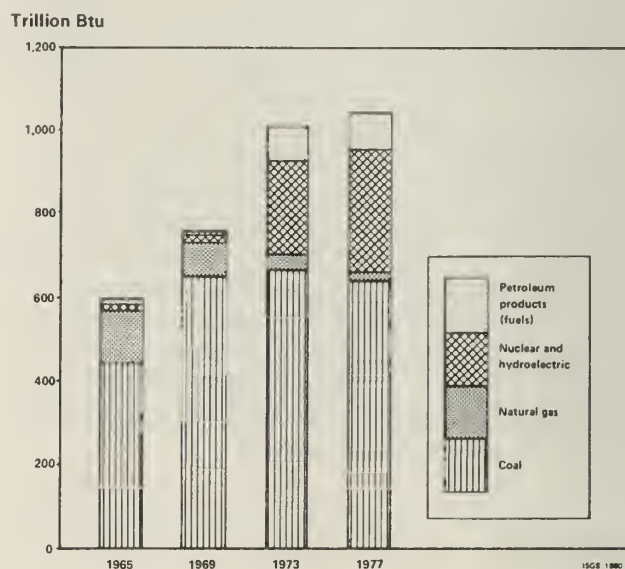


Figure 19. Sources of energy for electricity generation in Illinois.
Source of data: Illinois Institute of Natural Resources.

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